Stochastic reduced-order model for complex beam-like dynamical structures

Anas Batou, Christian Soize

Stochastic reduced-order model for complex beam-like dynamical structures

A. Batou[†], C. Soize[†] [*]

[†]Université Paris-Est, Laboratoire Modélisation et Simulation Multi Echelle,
MSME UMR 8208 CNRS,
5 bd Descartes, 77454 Marne-la-Vallee, France
email: anas.batou@univ-paris-est.fr,christian.soize@univ-paris-est.fr

Keywords: reduced-order model, beam-like structures, uncertainties, low frequency range.

This presentation is devoted to the construction of a stochastic reduced-order model for complex beam-like dynamical structures having a high modal density in the low frequency range. In general, dynamical structures exhibit well separated resonances in the low-frequency range. This low modal density allows classical methods (such as modal analysis) to be completed. This low-frequency range can clearly be separated from the medium-frequency range (for which the modal density is larger but not uniform in frequency). In some cases, in the low-frequency, a dynamical structure can exhibit both the global elastic modes (which characterize this low-frequency range) and numerous local elastic modes. This situation appears for complex heterogeneous structures presenting stiff parts and f exible parts. The presence of these f exible parts induces numerous local reasonance in the low frequency range (see Fig. 1). Furthermore, in this case, the elastic modes cannot be separated into global elastic modes and local elastic modes. Indeed, due to the coupling between global elastic modes and local elastic modes, the deformation of some global elastic modes have local contributions and the deformation of some local elastic modes have global contributions. Then there are no eff cient sorting method which could be used to select the elastic modes as global elastic modes or as local elastic modes. In addition, although the reduced-order model must be constructed with respect to the global elastic modes, this reduced-order model must have the capability to predict the amplitudes of the responses of the structure in this low-frequency range. Since there are local elastic modes in the frequency band, a part of the mechanical energy is transferred from the global elastic modes to the local elastic modes which store this energy and then induces an apparent damping at the resonances associated with the global elastic modes.

A classical method to construct a reduced-order model for complex beam-like structures consists in modeling these structures by simplif ed models using equivalent beams [2, 3]. Such a simplif ed model provides quite a good approximation of the global contributions of the displacements but can clearly not take into account the local contributions. Furthermore, the construction of an acurate simplif ed model cannot be carried out automatically and a procedure of validation of the simplif ed model is always needed.

The objective here is double: (1) The f rst one is to contruct a basis of global displacements and a basis of local displacements by solving two generalized eigenvalue problems. The elements of theses two bases will not be classical elastic modes (2) The second one is to construct a reduced-order model with the basis of the global displacements but in taking into account the effects of the local displacements, in order to correctly predict the frequency response functions in the low-frequency range. The local contributions which are very sensitive to uncertainties are taken into account using a probabilistic approach.

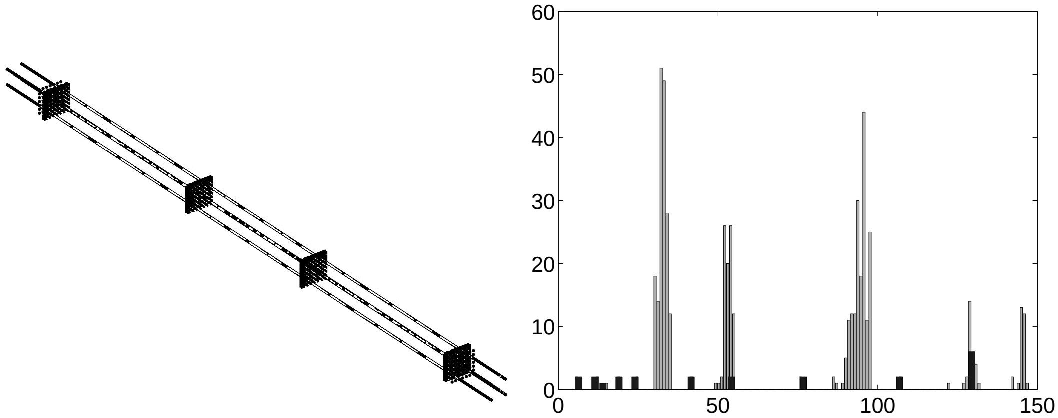

Figure 1: Complex slender structure (left f gure). Histograms of the associated eigenfrequencies (rigth f gure) : global elastic modes (black) and local elastic modes (grey). .

These two objectives are achieved using the method developed in [1]. This method is based on a kinematic reduction of the kinetic energy. Then, this reduced kinetic energy is used to construct a new global eigenvalue problem for which the solutions form a basis of global displacements. This basis can be completed with a basis of local displacements which is obtained by introducing a complementary kinetic energy, and then a local eigenvalue problem.

In this presentation we f rst develop the details of the methodology presented in [1]. Then, we present the application of this methodology to a complex slender struture made up of stiff beams and f exibles beams. The stochastic ROM we obtain allows the random dynamical responses to be calculated and as expected, the random responses show a low variability for the resonances corresponding to global displacements and a high variability for the resonances corresponding to local displacements.

References

[1] C. Soize, A. Batou: Stochastic reduced-order model in low-frequency dynamics in presence of numerous local elastic modes. *Journal of applied mechanics - Transactions of the ASME*, 78(6):061003, 2011.

[2] J. Planchard: Vibrations of nuclear fuel assemblies: a simplif ed model, *Nuclear engineering and design*. 86(3) 383–391., 1995.

[3] A.K. Noor, M.S. Anderson, W.H. Greene: Continuum Models for Beam- and Platelike-Lattice Structures. *AIAA Journal*, 16(12) 1219–1228, 1978.